

Part A – Multiple Choice

Questions 1-10 are worth 2 marks each, Questions 11 – 13 are worth 3 marks each

- D** 1. In a chemical reaction at constant temperature, the addition of a catalyst
- ~~a.~~ affects the equilibrium constant
 - b. decreases the energy released in the reaction
 - ~~c.~~ increases the concentration of the products at equilibrium
 - ☒ d. provides an alternate reaction pathway with a different activation energy
 - e. increases the collision frequency between molecules
- X D** 2. For the reaction system $2\text{HI}(\text{g}) \rightleftharpoons \text{H}_2(\text{g}) + \text{I}_2(\text{g})$, $K_c = 0.20$ at 720 K. If the initial concentrations of HI, H_2 , and I_2 are all $1.50 \times 10^{-3} \text{ M}$ at 720 K, which one of the following statements is correct?
- ~~a.~~ The system is at equilibrium.
 - ~~b.~~ The concentrations of HI and I_2 will increase as the system approaches equilibrium.
 - ~~c.~~ The concentrations of H_2 and HI will decrease as the system approaches equilibrium.
 - ~~d.~~ The concentration of HI will increase as the system approaches equilibrium.
 - ☒ e. The concentrations of H_2 and I_2 will increase as the system approaches equilibrium.
- X E** 3. Which of the following statements is **true** about the reaction $2\text{A} \rightarrow \text{B} + \text{C}$ which is first order in A and first order overall?
- ~~a.~~ The rate of the reaction will decrease at higher concentrations of B and C.
 - ☒ b. The time required for one half of A to react is directly proportional to the quantity of A.
 - ~~c.~~ The rate of formation of C is twice the rate of reaction of A.
 - ~~d.~~ The rate of formation of B is the same as the rate of reaction of A.
 - e. None of the above.
- A** 4. The oxidation of carbon monoxide proceeds as follows:
- $$2\text{CO}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{CO}_2(\text{g}) \quad \Delta H^\circ = -559 \text{ kJ}$$
- Which of the following will cause an increase in the equilibrium concentration of CO?
- ☒ a. decreasing the pressure of the system at constant temperature
 - ~~b.~~ decreasing the volume of the system at constant temperature
 - ~~c.~~ removing CO_2 from the system as it is formed
 - ~~d.~~ decreasing the temperature of the system
 - ~~e.~~ adding a catalyst
- B** 5. The sign of ΔH for the process $\text{H}_2\text{O}(\text{g}) \rightarrow \text{H}_2\text{O}(\text{l})$ is
- a. positive, and the process is exothermic
 - ☒ b. negative, and the process is exothermic
 - ~~c.~~ positive, and the process is endothermic
 - ~~d.~~ negative, and the process is endothermic
 - e. impossible to predict with confidence because ΔH°_f for $\text{H}_2\text{O}(\text{g})$ and ΔH°_f for $\text{H}_2\text{O}(\text{l})$ are not given.

- E 6. For which of the following reaction equations is the enthalpy change at 25 °C and 1 bar equal to ΔH°_f for formic acid, HCOOH (l)?
- $\text{CO}_2 (\text{g}) + \text{H}_2 (\text{g}) \rightarrow \text{HCOOH} (\text{l})$
 - $\text{CO} (\text{g}) + \text{H}_2\text{O} (\text{l}) \rightarrow \text{HCOOH} (\text{l})$
 - $\text{C} (\text{s}) + 2 \text{H} (\text{g}) + 2 \text{O} (\text{g}) \rightarrow \text{HCOOH} (\text{l})$
 - $\text{C} (\text{g}) + 2 \text{H} (\text{g}) + 2 \text{O} (\text{g}) \rightarrow \text{HCOOH} (\text{l})$
 - ~~C (s) + H₂ (g) + O₂ (g) → HCOOH (l)~~

- D 7. Consider the following specific heats of metals.

Metal	Specific Heat ($\text{Jg}^{-1}\text{°C}^{-1}$)
Copper	0.385
Cobalt	0.418
Chromium	0.447
Gold	0.129
Silver	0.237

$q = mc \Delta T$
 $q \propto c$

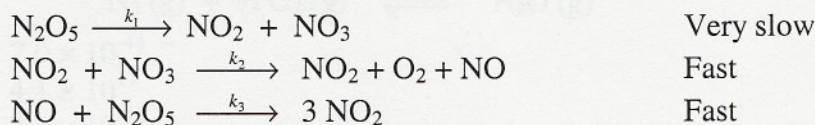
100 g samples of each of the metals at 95 °C are added to 100 mL of water at 25 °C. Which metal will increase the temperature of the water the **least**?

- copper
- cobalt
- chromium
- ~~gold~~
- silver

- X D 8. Which of the following has a standard enthalpy of formation equal to zero?

- $\text{H}_2\text{O} (\text{l})$
- $\text{O}_3 (\text{g})$
- ~~$\text{Br}_2 (\text{g})$~~
- $\text{Na} (\text{s})$
- $\text{C} (\text{diamond})$

- A 9. The following mechanism has been proposed for the decomposition of N_2O_5 :



The rate law that is applicable to the mechanism above is:

- ~~$k_1[\text{N}_2\text{O}_5]$~~
- $k_2[\text{NO}_2][\text{NO}_3]$
- $k_3[\text{NO}][\text{N}_2\text{O}_5]$
- $k_1k_2k_3[\text{N}_2\text{O}_5]^2$
- ~~$k_1k_2[\text{N}_2\text{O}_5][\text{NO}_2][\text{NO}_3]$~~

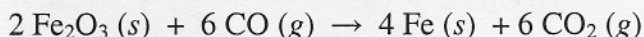
10. What is the change in internal energy of a system in which 20 J of work is done by the system on the surroundings and 5 J of heat is gained by the system from the surroundings?

- a. +15 J
- b. -25 J
- c. -15 J
- d. +25 J
- e. +20 J

$$\begin{array}{r} -20 \\ +5 \\ \hline -15 \end{array}$$

$$\Delta U = w + q \\ = -20 + 5 \\ = -15$$

11. Calculate the standard enthalpy change for the reaction



given the following data: $\Delta H_f^\circ [\text{Fe}_2\text{O}_3(s)] = -842.2 \text{ kJ}$ (-2) $\rightarrow 1684.4$
 $\Delta H_f^\circ [\text{CO}(g)] = -110.5 \text{ kJ}$ (-6) $\rightarrow 663.0$
 $\Delta H_f^\circ [\text{CO}_2(g)] = -393.5 \text{ kJ}$ (6) $\rightarrow -2361.0$

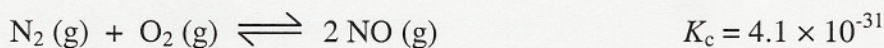
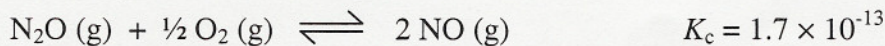
- a. 559.2 kJ
- b. -4708.4 kJ
- c. -13.6 kJ
- d. 13.6 kJ
- e. There is not enough information given in the question.

12. If a reaction is first order with a rate constant of $5.48 \times 10^{-2} \text{ s}^{-1}$, how much time will it take for $\frac{3}{4}$ of the initial concentration of reactant to be used up?

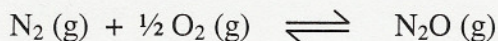
- a. 25.3 s
- b. 37.9 s
- c. 12.6 s
- d. 18.9 s
- e. 50.6 s

$$r = (5.48 \times 10^{-2}) [A]^1$$

13. Given the following data:



Find the value of the equilibrium constant for the following equilibrium reaction:



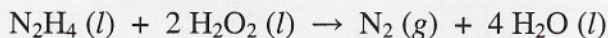
- a. 7.0×10^{-44}
- b. 4.1×10^{17}
- c. 2.4×10^{-18}
- d. 1.6×10^{-9}
- e. 2.6×10^{-22}

$$K_c = (K_c)(K_c)$$

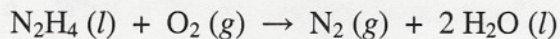
Part B – Problems

Each question is worth 5 marks. Show your work!

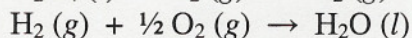
1. The following reaction is sometimes used to propel rockets.



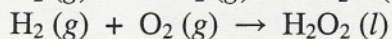
Determine ΔH° for the reaction from the following data:



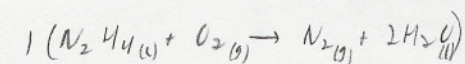
$$\Delta H^\circ = -622.2 \text{ kJ}$$



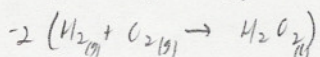
$$\Delta H^\circ = -285.8 \text{ kJ}$$



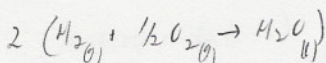
$$\Delta H^\circ = -187.8 \text{ kJ}$$



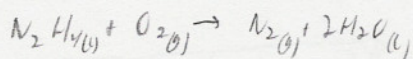
$$1 (\Delta H^\circ = -622.2 \text{ kJ})$$



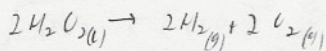
$$-2 (\Delta H^\circ = -187.8 \text{ kJ})$$



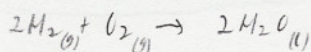
$$2 (\Delta H^\circ = -285.8 \text{ kJ})$$



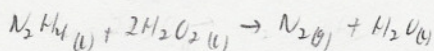
$$\Delta H^\circ = -622.2 \text{ kJ}$$



$$\Delta H^\circ = 375.6 \text{ kJ}$$



$$\Delta H^\circ = -571.6 \text{ kJ}$$

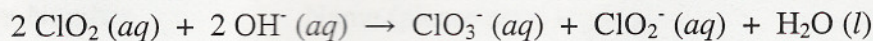


$$\Delta H^\circ = \boxed{-818.2 \text{ kJ}}$$

5/5

Part A /29	Part B /10	Total /39
25	1	26

2. The following data were obtained for the reaction



	$[\text{ClO}_2]_0 \text{ (molL}^{-1}\text{)}$	$[\text{OH}^-]_0 \text{ (molL}^{-1}\text{)}$	Initial Rate $\text{(molL}^{-1}\text{s}^{-1}\text{)}$
①	0.0520	0.110	5.75×10^{-2}
②	0.104	0.110	2.30×10^{-1}
③	0.104	0.0367	7.67×10^{-2}

a. What is the rate law for the reaction?

$$\frac{\text{rate}_1}{\text{rate}_2} = \frac{k [\text{ClO}_2]^x [\text{OH}^-]^y}{k [\text{ClO}_2]^x [\text{OH}^-]^y}$$

$$\frac{\text{rate}_2}{\text{rate}_3} = \frac{k [\text{ClO}_2]^x [\text{OH}^-]^y}{k [\text{ClO}_2]^x [\text{OH}^-]^y}$$

$$\frac{5.75 \times 10^{-2}}{2.30 \times 10^{-1}} = \frac{(0.0520)^x (0.110)^y}{(0.104)^x (0.110)^y}$$

$$\frac{2.30 \times 10^{-1}}{7.67 \times 10^{-2}} = \frac{(0.104)^x (0.110)^y}{(0.104)^x (0.0367)^y}$$

$$0.25 = 0.5^x$$

$$\ln(0.25) = x \ln(0.5)$$

$$x = 2$$

$$3 = 3^y$$

$$\ln 3 = y \ln(3)$$

$$y = 1$$

$$\text{rate} = k [\text{ClO}_2]^2 [\text{OH}^-]^1$$

b. What is the value of the rate constant for the reaction?

$$\text{rate}_1 = k [\text{ClO}_2]^2 [\text{OH}^-]^1$$

$$0.230 \text{ M/s} = k [0.104 \text{ M}]^2 [0.110 \text{ M}]^1$$

$$0.230 \text{ M/s} = k (1.20 \times 10^{-3} \text{ M}^3)$$

$$k = 193.32 \text{ M}^{-2} \text{ s}^{-1}$$

$$k = 193 \text{ M}^{-2} \text{ s}^{-1}$$

Well done.

Part A /29	Part B /10	Total /39
23	10	33

85%